A Black Array of Broadband Absolute Radiometers (BABAR) for Spectral Measurements of the Earth

Completed Technology Project (2018 - 2020)

Project Introduction

Spectral measurements from space are utilized in many areas, for example solar irradiance monitoring, urban land-use and population growth, water quality assessment, fire detection and monitoring, natural disaster damage assessment, soil and vegetation monitoring, and weather prediction and monitoring. For moderate- to low- resolution applications in the mid-wave infrared (MWIR) and long-wave infrared (LWIR) wavelengths, uncooled microbolometer linear arrays provide a solution that can be incorporated onto SmallSats and CubeSats. Existing arrays typically have a five micron spectral response range and require calibration with external, on-board blackbodies. We propose a three-year technology development effort that will demonstrate a MEMS uncooled microbolometer linear array with spectral response from the visible through the LWIR and with integrated electronics that incorporate electrical substitution calibration on-chip. A vertically aligned carbon nanotube (VACNT) absorber will be integrated onto each element's thermistor, and existing flight-proven electrical substitution electronics will be adapted for use in an array. The near-unity absorption and wide spectral range of the carbon nanotube absorber enable the replacement of the resonant optical cavity typically used in existing microbolometer arrays to enable a broadband detector with higher sensitivity than is currently available. By including electrical substitution capabilities, each individual microbolometer element can be absolutely calibrated without the need for an on-board blackbody. Closed-loop operation of the electrical substitution circuitry will provide excellent linearity and a large dynamic range. A new concept for monitoring the voltage drift of an on-orbit electrical substitution radiometer (ESR) by comparing the voltage reference of the microbolometer thermistor bridge to the existing satellite ultra-stable GPS signal through a voltage-controlled oscillator will be demonstrated. The two greatest technical challenges of this effort are the development of thermistors for microbolometer arrays that can withstand the high temperature of carbon nanotube growth and adaptation of existing thermistor bridge and electrical substitution electronics developed for single bolometers to linear arrays. We propose to work on both challenges simultaneously, with the first year dedicated to choosing and testing thermistor materials and identifying appropriate electronic components, the second year dedicated to demonstrating a linear microbolometer array and electronics performance, and the third year dedicated to integrating the linear microbolometer array with the electronics. The proposed work will reduce size, weight, and power (SWAP) requirement for IR imaging instruments by removing the need for a blackbody on-orbit while maintaining calibration and linearity. The incorporation of carbon nanotube absorbers increases the achievable spectral bandwidth. Such a detector will find use in a wide variety of Earth-imaging applications. The existing technology is currently at Technology Readiness Level (TRL) of 2. We anticipate a TRL of 4 upon completion of the work.

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Organizational Responsibility

Responsible Mission Directorate:

Science Mission Directorate (SMD)

Lead Organization:

National Institute of Standards and Technology (NIST)

Responsible Program:

Advanced Component Technology Program

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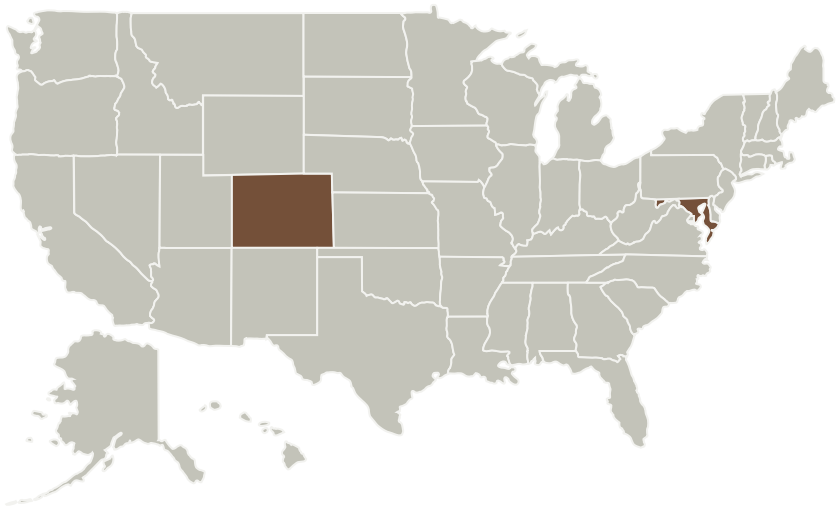
Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
National Institute of Standards and Technology(NIST)	Lead Organization	US Government	Boulder, Colorado
University of Colorado Boulder	Supporting Organization	Academia	Boulder, Colorado

Primary U.S. Work Locations	
Colorado	Maryland

Project Management

Program Director:

Pamela S Millar

Program Manager:

Amber E Emory

Principal Investigator:

Michelle Stephens

Co-Investigators:

Erik C Richard
David Harber
Julie Weiblinger

Technology Areas

Primary:

- TX08 Sensors and Instruments
  - TX08.1 Remote Sensing Instruments/Sensors
    - TX08.1.1 Detectors and Focal Planes

Target Destination

Earth